Space Enterprise Council



Space Transportation Working Group

Lunar Surface System Risk Assessment

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STWG - Lunar Surface System Risks Effort - Objective & Approach



Define candidate risks associated with Lunar Surface System Operations

- Build on the STWG Lunar Surface System (LSS) Standards effort completed in 2008
- Address the incremental implementation of LSS capability using ESMD LSS Provided Data
- For the selected candidate risks, identify potential approaches for mitigating those risks

Goal is to provide ESMD with a list of risks and their assessment by the end of June 2009

STWG - Lunar Surface System Risks Effort - Scope of Interest



- As part of this risk assessment we will look at several scenarios defined by NASA ESMD
- One set of scenarios is the incrementally build and operate a lunar colony and we will focus on two snapshots in time
 - Initial Surface Capability (ISC) outpost snapshoot
 - Continuous Human Presence Capability (CHPC) outpost snapshoot
 - We will also look at the impact on ISC and CHPC of solar power vs nuclear power
- A second scenario we will look at are Sortie missions that occur in parallel with the buildup of the outpost (not associated with the outpost)
- Definitions and configurations for these scenarios have been provided to the STWG by NASA ESMD in support of this effort

STWG - Lunar Surface System Risks Effort - Multiple Configurations



Initial Surface Capability (ISC)



- Includes assessing impact of Solar vs Nuclear power
- •Includes NASA and International Partner provided colony capability*

Continuous build up of Colony

Continuous Human Presence Capability (CHPC)



Multiple Sortie Missions to other Lunar Sites







^{*} This STWG effort does NOT include contact with International Partners

STWG - Lunar Surface System Risks Effort - Team



| NASA ESMD | STWG Risk Effort | | | | | | | |
|--|--|--|--|--|--|--|--|--|
| Leadership | | | | | | | | |
| John Olson & Nantel Suzuki | Linda Karanian | | | | | | | |
| Technical Effort Leader | | | | | | | | |
| Chris Culbert & Matt Leonard | Tom Cummings | | | | | | | |
| STWG LSS Risk Study Core Team Members | | | | | | | | |
| Scott Winter, David Lengyel & Gary Spexarth | Adam Dissel, Joe Pellegrino & John West | | | | | | | |
| Individual Risk Focals (One per selected risk) | | | | | | | | |
| TBD | TBD | | | | | | | |
| STWG LSS Risk Study Team Members | | | | | | | | |
| TBD | | | | | | | | |

The STWG LSS Risk Study Team will have individuals participating from across the SEC.

STWG - Lunar Surface System Risks Effort - Products



- Initial Product Approach, plan and schedule for the effort
- 1st Intermediate Product Prioritized list of candidate risks with a narrative description of the risks

- 2nd Intermediate Product Updated list of risks with possible mitigation approaches, mapped to the revised matrix from the standards effort
- Final Product Compile results of effort into a spreadsheet that captures all of the information

STWG – LSS Risks Effort Groundrules and Assumptions



- We will address lunar surface operations risks but not the risk to design, develop, or deploy the LSS elements
 - The risk mitigation approaches may take you to those program phases to mitigate the risk
- We will reuse the three types/families of scenarios we did for the LSS standards work
 - 1) Resupply and housekeeping
 - 2) Science and exploration
 - 3) Emergencies
 - We will define about 6 scenarios for each of the three types to be used for the study
- We assume the lunar outpost operations are autonomous from Earth operations (the colony will contact Earth when they want or need to)
- For the Sortie missions scenarios we will look at post landing operations (we will not address the actual landing aspects of the lander)

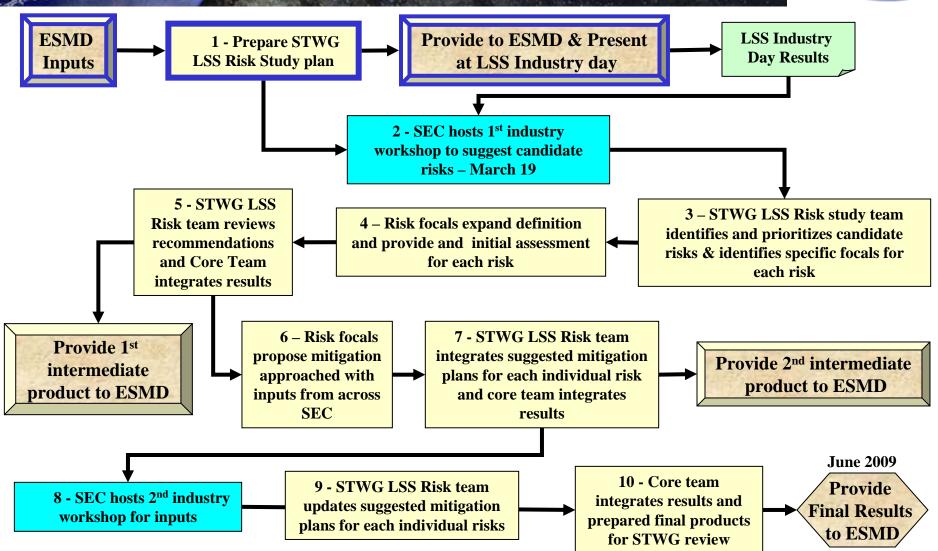
STWG – LSS Risks Effort Groundrules and Assumptions (cont.)



- The outpost will include unmanned cargo landers and we will focus on a recyclable lander and how to use the lander in context as a resource for the outpost
- We will compile a list of candidate risks and then rank them in relative importance to select the TBD number of the top risks from that list that we will follow thru to the end of this effort
- For the solar vs nuclear aspect, we are not trading between those two options but instead will focus on how each of those two options impact the ISC and CHPC operations
- We assume communication and navigation for both the sortie and lunar colony are in place for operations, but we can look at their contribution to the lunar operations risks

STWG – LSS Risks Effort Plan and Status as of 2/25





Lunar Surface Systems Element and Manifest Overview



CONSTELLATION



Background



- The NASA Lunar Surface Systems Office is still in the stage of formulating and analyzing various architectures.
- ◆ All data contained herein is notional; there has been no selection of a "baseline" architecture at this time.
- No distinction has been made as to which assets may be provided by NASA, contractors, commercial entities, or international partners.



Lunar Surface Scenarios Families



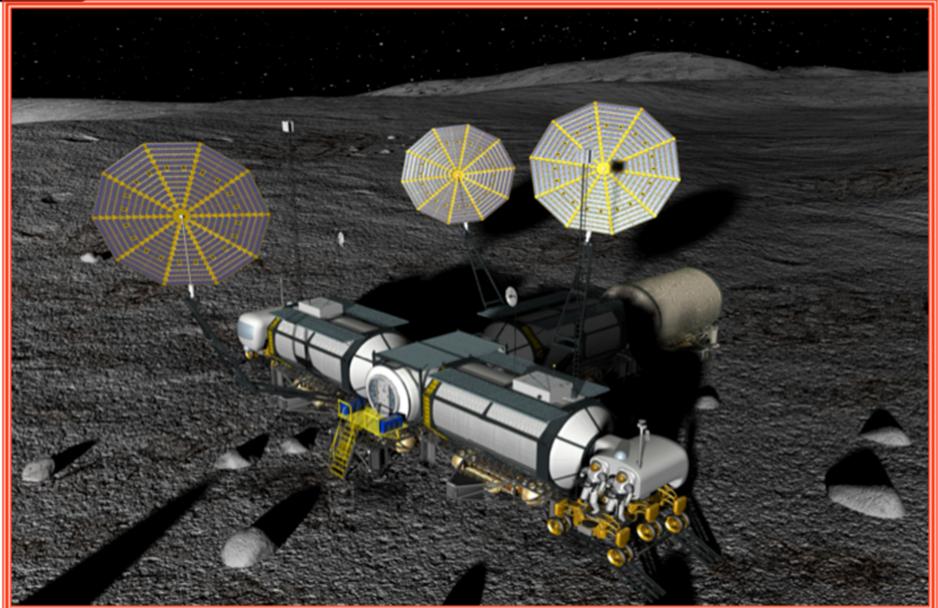
| Scenario | Description |
|----------|---|
| 1 | Full Outpost Assembly from LCCR (Trade Set 1) |
| 2 | Mobility oriented Outpost from LCCR (Trade Set 2) |
| 3 | Habitation oriented Outpost from LCCR (Trade Set 3) |
| 4 | Rebuild of LCCR scenarios increasing crew flights to at least 2 per year |
| 5 | Nuclear power based scenarios – Use a fission reactor as the primary power source |
| 6 | Power beaming scenarios – Consider ways to beam power from orbit or surface to systems |
| 7 | Recyclable lander – Scenarios that make massive reuse of lander components to build up the Outpost and surface infrastructure |
| 8 | Extreme mobility – Scenarios that deploy Small Pressurized Rovers early and use them as primary habitation |
| 9 | Improving Lander offloading – Scenarios that support a lander configured to make unloading much less complex |
| 10 | Refuelable lander – Scenarios that support a lander designed for multiple flights to and from LLO |
| 11 | Mars Centric – Scenarios that optimize Mars exploration ties |

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Scenario 4.2.1 Initial Surface Capability Configuration

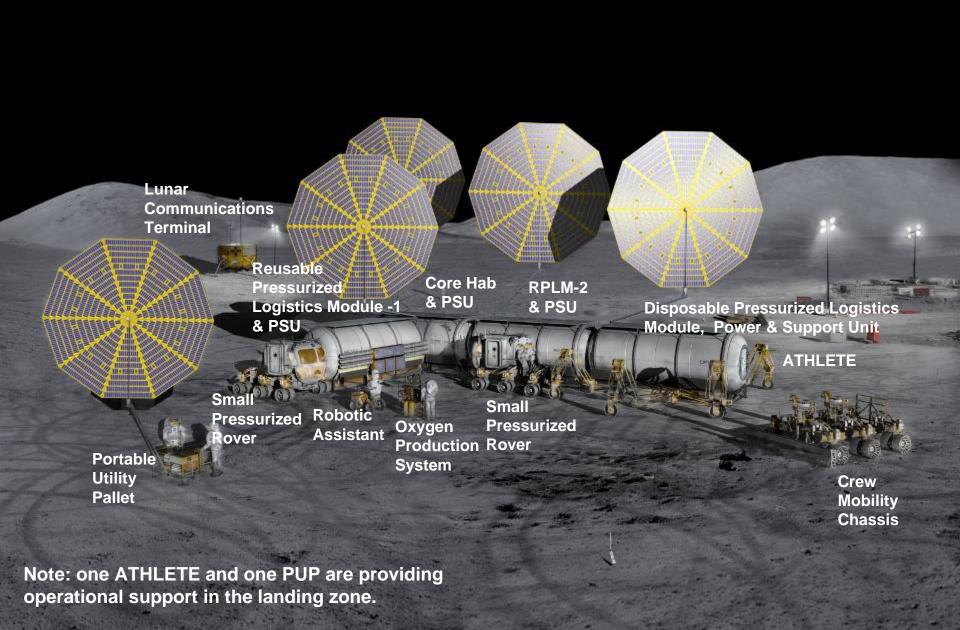






Scenario 4.2.1 Continuous Human Presence Capability Configuration



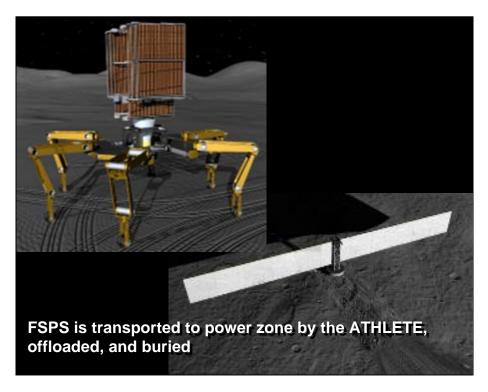




Scenario-5 Fission Surface Power (FSP)



- ♦ Scenario-5 is very similar to Scenario-4, but it uses Fission Surface Power (FSP) instead of Solar for the primary power source.
- Scenario 5.0.2: Off-Loaded & Buried
 - Lowest mass FSPS
 - Reactor can be located close to outpost (100 m)
 - Requires 2.3 m deep hole
 - ATHLETE digs hole; moves FSPS to site; places FSPS in hole



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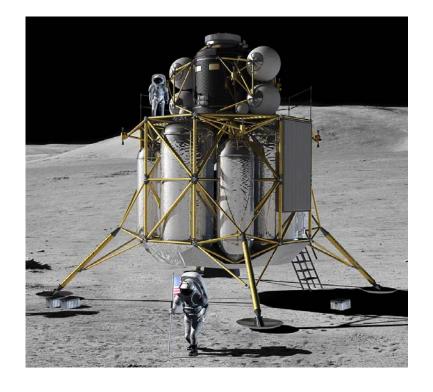
Sortie Missions



 Crew lives and works out of the lander at some site remote from the lunar colony site

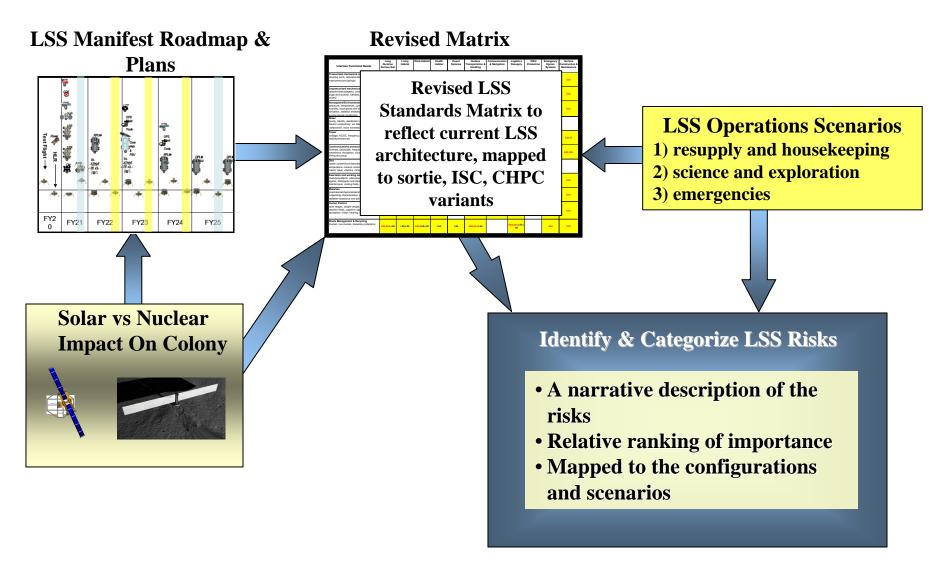
 STWG Risk Assessment will look at the same three types of scenarios as we will for the colony, only in context of one week

sortie missions



STWG - Lunar Surface System Risks Effort - Risk Identification Process





STWG - Lunar Surface System Risks Effort - Identify The Risk



- For each risk there needs to be a narrative description
 - Simple top level identifier as the name of the risk so we can track it
 - The STWG core team will assign numbers to the risks that are down selected from the brainstorming effort
 - Name of STWG representative person who will be owner of that risk and their company
 - This is the person who will present that risk through this STWG effort
 - A general description of this risk
 - Context of what would cause the risk and what events, functions, scenarios, or elements would be involved with the risk
 - Groundrules and assumptions used to define the risk
 - Why it's important to consider this risk
 - Program phase/type (Sortie, ISC, CHPC or some combination) that will incur the risk
 - Type of risk (Program Management, Safety, Performance, Schedule, Cost, other)
- This will later be followed by defining and assessing a potential risk mitigation approach

STWG - Lunar Surface System Risks Effort - Map The Risk

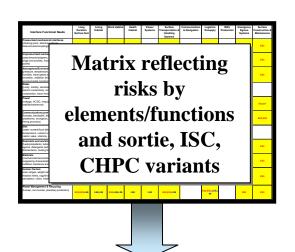


| Interface Functional Needs | Surface Suit | Living Habitat | Work Habitat | Health Habitat | Power Systems | Surface Transportation & Handling Systems | Communication & Navigation | Logistics Resupply | ISRU Production | Emergency Egress Systems | Surface Construction & Maintenance | Scientific Instruments & Equipment | |
|---|--|----------------|--------------|----------------|---|--|----------------------------|-----------------------|-----------------|-----------------------------|--|--|--|
| Pressurized mechanical interface: (docking ports, airlocks/suitlocks, interconnects/couplings) Unpressurized mechanical interfa (attachments/adapters, connectors, plugs and sockets, handles, hard/lift points) Atmosphere/Environmental (pressure, temperature, composition humidity, trace gases and contamina ionization, radiation shielding & hard environmental monitoring) Water (purity, sterility, sterilityation approact | the | risk Put th | e Ris | | lumbe | | | | are i | | | | |
| electric conductivity, ion balance, isc composition, trace minerals) Power (voltage, AC/DC, frequency, stability/tolerances) Communications protocol (formats, bandwidth, frequencies, waveforms, encryption, clock speed timing accuracy) Diet (water content/food dehydration, sto temperature, nutrient content, compcaloric value, vitamins, minerals) | Identify which Program Phase first incurs the risk Is, AC/DC, frequency, syltolerances) Initiations protocol ts, bandwidth, frequencies, torms, encryption, clock speed accuracy) ISC = I CHPC = C | | | | | | | | | | | | |
| Reactants and working media (fuels/propellants, lubricants, CO2 re agents, detergents and cleaners, disinfectants, cooling fluids, catalysts) | × | x | × | X | × | x | | × | × | × | x | × | |
| Materials (mechanical/chemical/electrical properties, outgassing characteristics, UV resistance, radiation resistance and penetrability) | x | х | x | х | Exan | nple: I | f Risk | Numb | er 3 of | f the p | rioriti | zed | |
| Human Factors (size ranges, weight ranges, metabolic rates, reaction times, cognitive capabilities and perception, vision, hearing, reach, strength) | x | x | 3-I - | | list first occurs in the ISC Program Phase, would have "3-I" in the box that involves | | | | | | | | |
| Waste Management & Recycling (human, non-human, planetary protection) | х | x | x | х | that element and function. | | | | | | | | |
| Navigation (real-time surface location, geographic features, hazard identification) | х | | | | х | х | х | х | | х | х | х | |

STWG - Lunar Surface System Risks Effort - Risk Mitigation Suggestions



- •A narrative description of the risks
- Relative ranking of importance



- Suggest mitigation approach for each selected prioritized risk
- Link mitigation approach to applicable Program Phase
- Assess feasibility of suggested approaches
 - > Is it executable and addresses the risk?

STWG - Lunar Surface System Risks Effort - Summary



- Will use broad industry participation facilitated by STWG similar to LSS Standards effort
- We are focused on LSS Risk products and results that maximize benefit to NASA
 - Configurations to be assessed are the incremental buildup and operations using scenario 4.2.1.20 as impacted Solar vs Nuclear, and sortie missions
 - The product of this study will be a narrative description of the risks supported by a matrix capturing the relationship of the risk to LSS elements and functions
- ESMD/Constellation has provided LSS configuration information and will collaborate with the STWG team throughout the study

All SEC Members are invited to join us at the March 19th workshop and throughout the study